Armed Forces College of Medicine

AFCM

Basal ganglia

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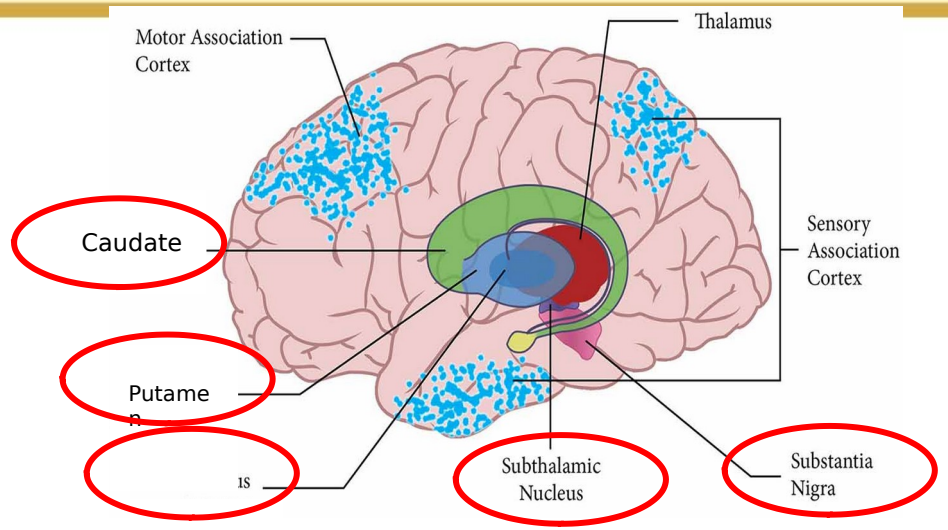
INTENDED LEARNING OBJECTIVES (ILO)

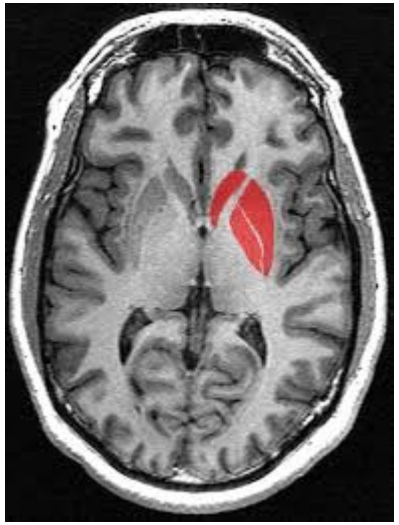
By the end of this lecture the student will be able to:

1. List the BG nuclei and the functionally associated centers.
2. List the functions of the basal ganglia.
3. Illustrate the role of dopamine in direct and indirect circuits.
4. Describe mechanism of Parkinson’s diseases.
5. Explain the cause of tremors and rigidity in Parkinson’s disease.

Anatomy of the Basal Ganglia



https://upload.wikimedia.org/wikipedia/commons/8/8c/Cortical_surface_with_an_overlay_of_the_basal_ganglia_and_thalamus.jpg



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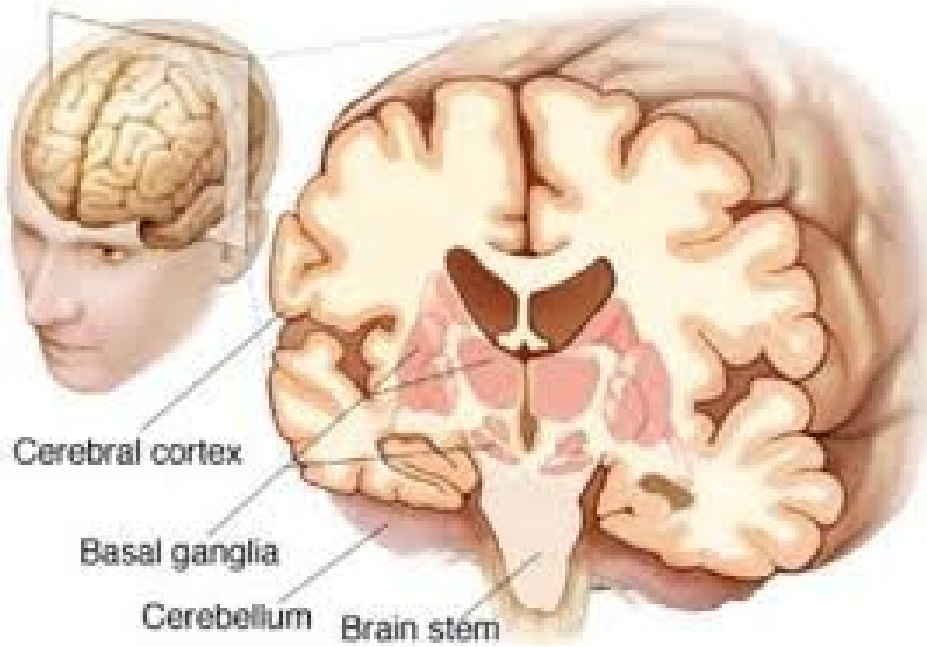

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Anatomy of the Basal Ganglia

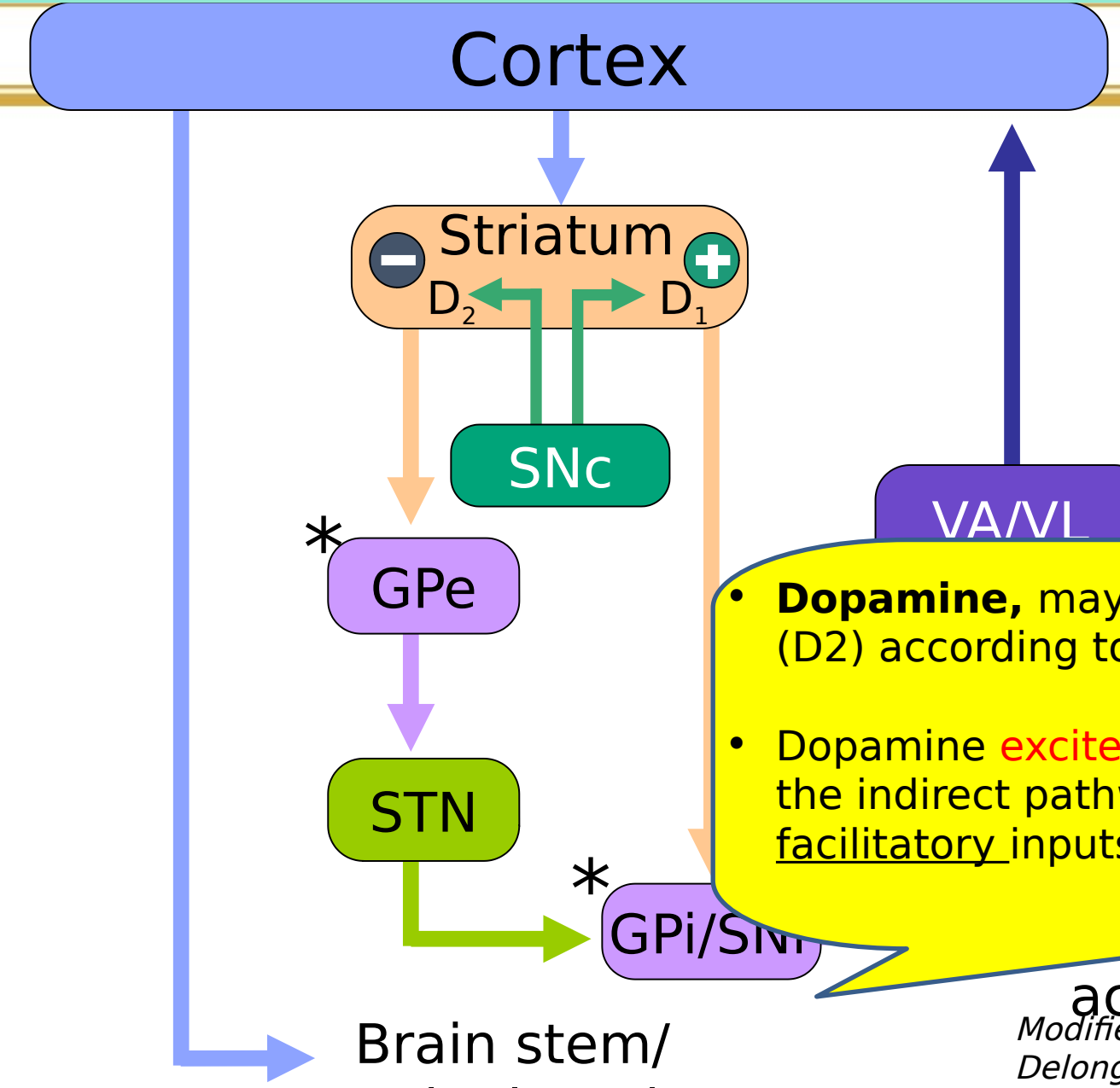
- **Caudate nucleus.**
- **Putamen nucleus.**
- **Globus pallidus:**
  (internal and external parts)

Corpus Striatum

Lenticular nucleus

- **Subthalamic nucleus.**
- **Substantia nigra.**
  (pars compacta & pars reticulata).

Role of dopamine in direct & indirect circuits



- **Dopamine,** may be **excitatory** (D1) or inhibitory (D2) according to the receptor.
- Dopamine excites the direct pathway and inhibits the indirect pathway, with a net effect to increase facilitatory inputs to the motor regions.

Modified from Wichmann and Delong, Curr Opin Neurobiol. 6:751-758, 1996.

Functions of the Basal Ganglia (Motor)

1- Cognitive control of sequences of motor patterns

Planning & programming

to "***select***" and "***p***
sequence" the mo
achieve a complex goal

Neurones of the BG discharge **before** movements begin.

Thought → voluntary action

2- Timing and scaling of movements

Determines *how large* (= spatial dimensions) and *how fast* the movement will be

https://www.euroformhealthcare.biz/medical-physiology/function-of-the-basal-ganglia-to-change-the-timing-and-to-scale-the-int

Functions of the Basal Ganglia (Motor)

Execution of proper movement

putamen circuit

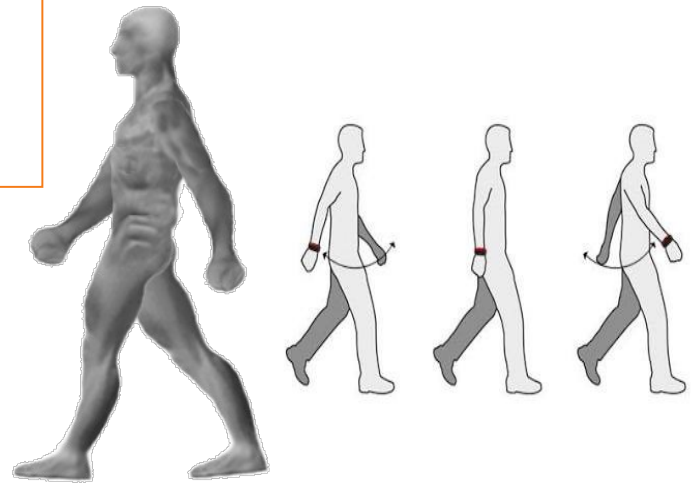
3- Execution of subconscious learned patterns of movement

e.g. cutting with scissors
some aspects of vocalization

4- Initiation and regulation of the gross associative movements of the body

e.g. swinging of arms and facial expression

https://www.livescience.com/44494-human-facial-expressions-compound-emotions.html



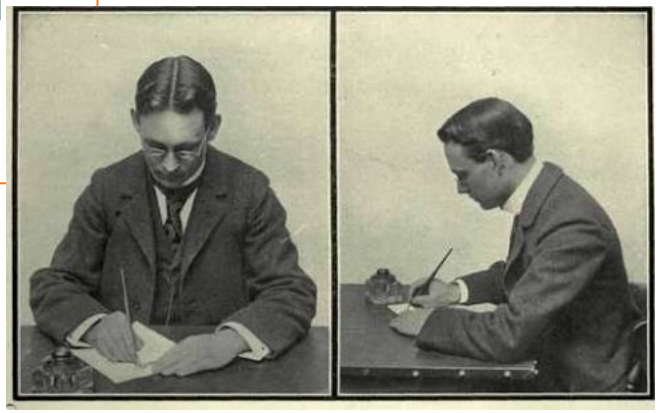
https://en.wikipedia.org/wiki/Arm_swing_in_human_locomotion#/media/File:Walk-Cycle

Functions of the Basal Ganglia (Motor)

The globus pallidus

5- Responsible for the posture taken by the body to perform a particular voluntary movement

It locks the different parts of the body into a specific position so as to facilitate the fine movements of the hand.



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6- Inhibitory to muscle tone

(Damage → Rigidity)

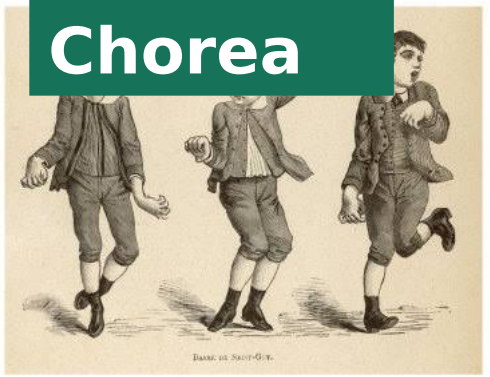
Diseases of the basal ganglia in human

- Normal function of the BG is brought about by a balance between the various excitatory and inhibitory influences of the various transmitters.

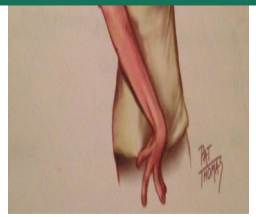
- Diseases of the BG lead to 2 general types of disorders; hyperkinetic (1,2&3) and hypokinetic (akinesia & bradykinesia)

- BG dysfunction does NOT cause paralysis, sensory loss or ataxia but leads to abnormal involuntary movement & change in ms. Tone (hypertonia or hypotonia).

1- Chorea



2- Athetosis



http://absorbmedicine.blogspot.com/2013/11/causes-of-chorea-medical-mnemonics.html

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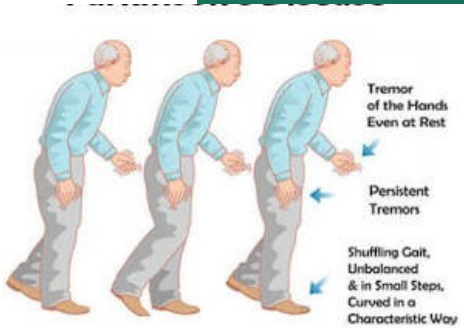
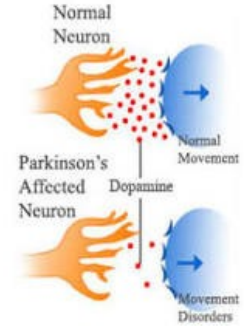




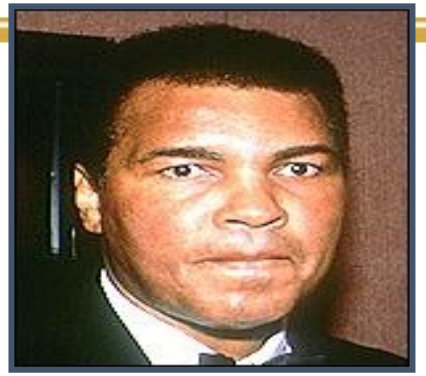
https://studfiles.net/preview/396004/page:8/ https://www.dailyhealthguard.com/treating-parkinsons-disease-new-a

Parkinson's disease = paralysis agitans

Cause .

Loss of dopaminergic influence

Michael J. Fox



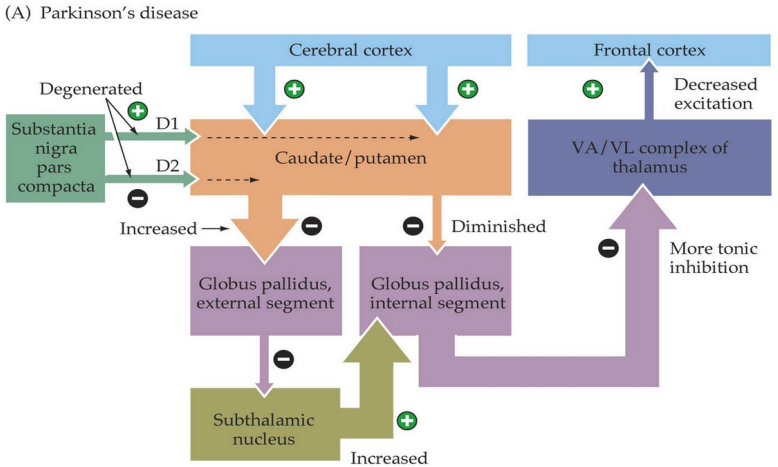
Muhammad Ali

Pope John Paul II

Treatment:

L-dopa

Mechanis



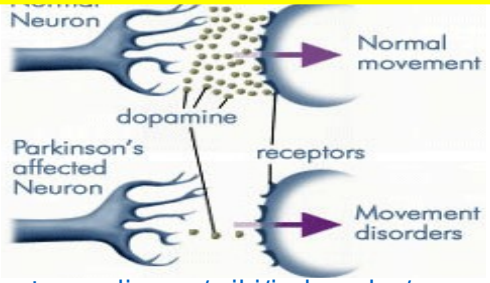
https://www.slideshare.net/CsillaEgri/cerebellum-and-basal-ganglia

Manifestations:

1- Rigidity:

2-*Bradykinsesia / Akinesia*:

3- Tremors:



https://proteopedia.org/wiki/index.php/xylase

Parkinson's disease = paralysis agitans

Manifestations

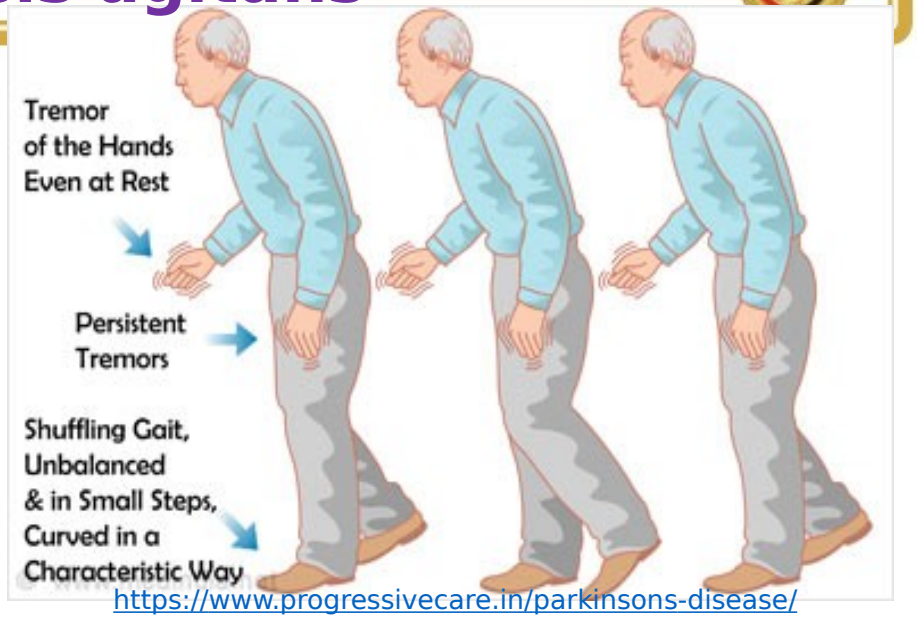
1- *Bradykinsesia / Akinesia*:

Bradykinesia: movements take longer time.

Akinesia: difficulty in initiating movement.

- ❑ **Monotonous speech**
- ❑ **Mask face**
- ❑ **Gait: short steps + shuffling**

loss of swinging arm movements



https://www.progressivecare.in/parkinsons-disease/

https://www.youtube.com/watch?v=j86omOwx0Hk

Parkinson's disease = paralysis agitans

Manifestations

2- Rigidity:

- **Increased impulses transmitted along the corticospinal tract to <u>both</u> α- and γ- motor neurons**
- **<u>lead pipe</u> rigidity or <u>Cogwheel</u> rigidity**
- **Flexors > extensors**

https://practicalneurology.com/patients-caregivers/movement-disorders

Parkinson's disease = paralysis agitans

Rigidity versus spasticity

	Rigidity	Spasticity
1- Cause	Parkinsonism	**UMNL**
2-Mechanism:	Facilitation of both types of the AHCs; the alpha(α) and gamma(γ)	Facilitation of the gamma (γ) type only.
3-mainly affected muscles:	Flexors mainly	Antigravity muscles mainly.
4-Attitude:	Generalized flexion	Hyperextension of LL.
5-Reflexes:	.....	Exaggerated.
6-Associated features:	Static tremors	clonus
7-Described as	Cog wheel/ lead pipe	clasp knife

Parkinson's disease = paralysis agitans

Manifestations

3- Tremors:

- Involuntary rhythmic alternating contractions of antagonistic muscles
- Pill rolling at the hand or up & down movement of the mandible.
- Frequency of 4-6/sec.
- Present at rest - disappear during voluntary movements and sleep.

Parkinson's disease = paralysis agitans

Treatment

1- L-dopa Dopamine precursor, Can cross BBB

2- Anti-cholinergic drugs

3- Surgical treatment

- **Lesion in GPi (Pallidotomy) or subthalamic nuclie**
- **Implantation of electrodes**

4- Implantation of dopamine-secreting tissue

Diseases of the basal ganglia in human

	1- Chorea	2- Athetosis	3- Ballism	4- Parkinsonism
Lesion	Caudate & putamen	Globus pallidus	Subthalamus	Substantia nigra
Cause / mechanism	Hereditary)**Huntington's chorea**(Or rheumsatic (Swdenham's chorea) Damage of neostriatum (GABA) of the indirect pathway removal of inhibition of substantia nigra and globus pallidus allows spontaneous outbursts of their activity abnormal movements	Wilson's disease where ceruloplasmin is low, there is chronic copper intoxication degeneration of lenticular .nucleus	Vascular lesion	i- Cerebral atherosclerosis loss of dopamine receptors. ii - Head trauma. Iii- Phenothiazine drugs block D2 dopamine receptors Degeneration of dopaminergic neurons in SNpc; particularly fibers to the putamen (imbalance between excitation & inhibition in BG)
Tone	--- (+ pendular knee jerk)	+++	---	+++ (rigidity)
Involuntary movemen	Spontaneous, rapid, involuntary dancing	Continuous, slow writhing (worm-like) movements of the hands	Rapid, flailing, intense and violent	Static tremors

Lecture Quiz

Parkinson’s disease is caused by a lesion in:

a. Posteroventral nucleus of the thalamus.

b. substantia nigra pars compacta

c. Substantia nigra pars reticulata.

d. Indirect circuit neurons of putamen.

Lecture Quiz

Parkinson's disease is characterized by:

a. Involuntary dancing like movements.

b. Hypotonia

c. Static tremors.

d. Spastic gait.

e. Clasp knife spasticity

References

1. **Guyton and Hall Textbook of Medical Physiology.**
   - **https://www.amazon.com/Guyton-Hall-Textbook-Medical-Physiology/dp/1455770051**

2. **Ganong’s Review of Medical Physiology, 25e.**
   - **https://www.amazon.com/Ganongs-Review-Medical-Physiology-Twenty-Fifth/dp/007182510X**
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Thank you